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The evolution of academic publications on pregnant women with COVID-19 and critical care: A holistic investigation of global outcomes with bibliometric analysis

Pregnancy and critical COVID-19 care

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Abstract
Aim: It was aimed to analyze scientific articles published on "pregnant with COVID-19, and critical care" by statistical and bibliometric methods.
Material and Methods: Articles published between 2019-2021 were obtained from the Web of Science database and analyzed using comprehensive bibliometric methods and citation analysis. Spearman correlation coefficient was used for correlation studies. Network visualization maps were created to analyze citations and identify trending topics.
Results: A total of 314 publications were found, of which 218 (69.4%) were articles. The top 5 contributors to the literature are the USA (32.5%), England (10.1%), Italy (8.7%), Spain (8.7%) and Turkey (7.7%). The top 3 journals with the most publications were BMJ Case Reports (4.1%), International Journal of Gynecology & Obstetrics (4.1%) and American Journal of Perinatology (3.7%).
Discussion: In this bibliometric study for "pregnant with COVID-19, and critical care", it can be said that the trend topics are depression, stress, childbirth, ARDS, breastfeeding, newborn and maternal outcomes. This article can help scientists and clinicians evaluate new treatment and critical care strategies.

Keywords
Pregnancy, Pregnant, COVID-19, Critical Care, Bibliometric Analysis

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Introduction

COVID-19 pneumonia was first reported in December 2019. It was later declared a global public health emergency by the World Health Organization [1,2]. At the beginning of the epidemic, the clinical features of pregnant with COVID-19 and non-pregnant adults were similar [1]. However, it has been reported that pregnant women with COVID-19 in the later period are more likely to be admitted to the critical care unit or need invasive mechanical ventilation compared to non-pregnant women of reproductive age. Ethnicity, chronic hypertension, diabetes, high maternal age and high body mass index were expressed as risk factors for severe COVID-19 pneumonia in pregnancy. It has also been reported that pregnant women diagnosed with COVID-19 are more likely to have premature birth and maternal death than pregnant women without COVID-19. Critical care follow-up may be required in cases of severe pneumonia, acute respiratory distress syndrome (ARDS), sepsis, septic shock, myocarditis, arrhythmia, cardiogenic shock and multi-organ failure in pregnant women with a diagnosis of COVID-19. Therefore, pregnant women with COVID-19 are considered to be a high-risk group [3,4,5]. Given that COVID-19 still persists and disease severity varies by variant, it is important to share experiences of pregnant women with COVID-19 and critical care.

Bibliometric research uncovers the most cited influential works, the most active authors, journals, and institutions in a topic or field. With keyword analyses obtained as a result of comprehensive statistical and bibliometric analyzes, researchers also give an idea about new studies that they can design by seeing past and current trends. Researchers who read the bibliometric outputs obtained as a result of the analysis of hundreds of studies published on a subject can dominate the literature in a short time [6-11].

We also thought that bibliometric analysis on pregnant with COVID-19, and intensive care would provide a better study of the impact of the disease on this population.

In this study, scientific articles published on "pregnant with COVID-19, and critical care" between 2019-2021 were analyzed using statistical and bibliometric methods. As a result of the analyses, it was aimed to determine the most cited influential studies, the most active authors, journals, institutions and countries, to reveal the cooperation between countries and trend topics, and to summarize the subject holistically.

Material and Methods

Web of Science (WoS) database (by Clarivate Analytics, USA) was used for literature review. The publication search was done in the Topic (title, abstract and keywords) section of the studies. Various keywords related to pregnancy, COVID-19 and critical care were used as search keywords in WoS. With this search method, in the title, abstract or in the keywords section, related to pregnancy, COVID-19 and critical care (pregnancy, pregnant, pregnancies, postpartum, post partum, maternal, COVID-19, coronavirus, SARS-CoV-2, n-CoV, critical care, critical care) were retrieved and downloaded from the WoS database. The search process was determined as 2019-2021 (access date: 01.11.2021). Due to the addition of new publications to the WoS database every day, the search findings may change at different access dates.

VOSviewer (Version 1.6.17, Leiden University's Center for Science and Technology Studies) package program was used for bibliometric network visualizations [12]. The website (https://app.datawrapper.de) was used for the World map drawing, which was created to show the distribution of articles by world countries. Statistical analyzes were performed with the SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA) package program. Whether the data were normally distributed or not was evaluated with the Kolmogorov-Smirnov test. In order to determine whether there is a relationship between the scientific work productivity of countries on pregnant with COVID-19, critical care and their economic power, the number of articles produced by the countries of the world and some economic development indicators of the world countries, gross domestic product (GDP), and GDP per capita (The World Bank-2020, Website accessed 10 October 2021, Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD,) were analyzed. Spearman correlation coefficient was used for the correlation analysis in accordance with the data distribution. Statistically significant difference limit was accepted as $P<0.05$.

Since this study is a bibliometric analysis, it does not require ethics committee approval.

Results

A total of 314 publications on "pregnant with COVID-19, and critical care" were found in the WoS database between 2019 and 2021. Of these publications, 218 (69.4%) were articles, 61 (19.4%) were reviews, 28 (8.9%) were letters, and the remainder were early access and editorial material. Bibliometric analyses were carried out with 218 articles from a total of

Table 1. The 20 most active journals that have published more than 3 articles on pregnant with COVID-19, and critical care

Journals	RC	C	AC
BMJ Case Reports	9	4	0.4
International Journal of Gynecology & Obstetrics	9	68	7.6
American Journal of Perinatology	8	27	3.4
Cureus	7	8	1.1
Journal of Maternal-Fetal & Neonatal Medicine	7	20	2.9
American Journal of Obstetrics & Gynecology MFM	6	123	20.5
Journal of Perinatal Medicine	6	8	1.3
Obstetrics and Gynecology	5	170	34.0
Trials	5	19	3.8
American Journal of Obstetrics and Gynecology	4	101	25.3
BJOG-An International Journal of Obstetrics and Gynaecology	4	129	32.3
Journal of Obstetrics and Gynaecology Research	4	3	0.8
Plos One	4	19	4.8
Ultrasound in Obstetrics & Gynecology	4	142	35.5
Acta Obstetricia et Gynecologica Scandinavica	3	82	27.3
Best Practice & Research Clinical Obstetrics & Gynaecology	3	2	0.7
BMC Pregnancy and Childbirth	3	16	5.3
European Journal of Pediatrics	3	27	9.0
Fertility and Sterility	3	6	2.0
Scientific Reports	3	2	0.7

C: Record Count, C: Number of Citation, AC: Average Citation Per Document

314 publications in the article category. Of these articles, 208 (95.4%) were published in English, 4 (1.8%) in Spanish, 3 (1.4%) in German, 2 (0.9%) in French, and 1 (0.5%) in Russian. The h-index of 218 articles was 20, average citations per article 9.2, sum of times cited 2005 (without self citations:1825).

1.1. Active Research Areas

Distribution of analyzed articles by research fields (at least 3 articles were published) was as follows: Obstetrics Gynecology (85, 38.9%), Medicine General Internal (52, 23.8%), Pediatrics (34, 15.5%), Infectious Diseases (14, 6.4%), Immunology (8,

Table 2. The top 20 most cited articles on study topic by total number of citations

No	Article	Author	Journal	PY	TC	AC
1	Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study	Knight, M. et al.	BMJ-British Medical Journal	2020	312	156
2	COVID-19 in Children, Pregnancy and Neonates: A Review of Epidemiologic and Clinical Features	Zimmermann, P. and Curtis, N.	Pediatric Infectious Disease Journal	2020	117	58.5
3	Vaginal delivery in SARS-CoV-2-infected pregnant women in Northern Italy: a retrospective analysis	Ferrazzi, E. et al.	BJOG-An International Journal of Obstetrics and Gynaecology	2020	114	57
4	Prevention and Control of Seasonal Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices - United States, 2020-21 Influenza Season	Grohskopf, LA. et	MMWR Recommendations And Reports	2020	84	42
5	Public Health Agency of Sweden's Brief Report: Pregnant and postpartum women with severe acute respiratory syndrome coronavirus 2 infection in intensive care in Sweden	Collin, J. et al.	Acta Obstetricia et Gynecologica Scandinavica	2020	76	38
6	Clinical role of lung ultrasound for diagnosis and monitoring of COVID-19 pneumonia in pregnant women	Buonsenso, D.et al.	Ultrasound in Obstetrics & Gynecology	2020	71	35.5
7	Clinical characteristics of 46 pregnant women with a severe acute respiratory syndrome coronavirus 2 infection in Washington State	Lokken, EM. et al.	American Journal of Obstetrics and Gynecology	2020	70	35
8	Coronavirus disease 2019 in pregnancy: early lessons	Breslin, N. et al.	American Journal of Obstetrics & Gynecology MFM	2020	68	34
9	Clinical Findings and Disease Severity in Hospitalized Pregnant Women With Coronavirus Disease 2019 (COVID-19)	Savasi, VM. et al.	Obstetrics and Gynecology	2020	65	32.5
10	Environmental contamination of SARS-CoV-2 in healthcare premises	Ye, G. et al.	Journal of Infection	2020	65	32.5
11	Characteristics and Outcomes of 241 Births to Women With Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection at Five New York City Medical Centers	Khoury, R. et al.	Obstetrics and Gynecology	2020	64	32
12	Outcomes of Neonates Born to Mothers With Severe Acute Respiratory Syndrome Coronavirus 2 Infection at a Large Medical Center in New York City	Dumitriu, D. et al.	JAMA Pediatrics	2021	51	25.5
13	Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection	Saccone, G. et al.	Ultrasound in Obstetrics & Gynecology	2021	49	49
14	Two cases of coronavirus 2019-related cardiomyopathy in pregnancy	Juusela, A. et al.	American Journal of Obstetrics & Gynecology MFM	2020	48	24
15	Therapeutic plasma exchange in adults with severe COVID-19 infection	Khamis, F. et al.	International Journal of Infectious Diseases	2020	43	21.5

PY: Publication year, TC: Total citation, AC: Average citations per year

Table 3. The 53 most frequently used keywords in articles about pregnants with COVID-19, and critical care

Keywords	Number of uses	Keywords	Number of uses	Keywords	Number of uses
COVID-19	135	intensive care	5	depression	3
pregnancy	87	perinatal	5	maternal death	3
SARS-CoV-2	59	pneumonia	5	maternal health	3
coronavirus	24	breastfeeding	4	maternal morbidity	3
pandemic	11	extracorporeal membrane oxygenation	4	maternal outcome	3
coronavirus disease 2019	10	intensive care unit	4	maternal outcomes	3
vertical transmission	9	novel coronavirus	4	neonatal outcome	3
critical care	8	pregnancy outcomes	4	neonatal outcomes	3
mechanical ventilation	8	protocol	4	neonate	3
preterm birth	8	randomised controlled trial	4	obesity	3
severe acute respiratory syndrome coronavirus 2	8	risk factors	4	postpartum	3
mortality	7	symptoms	4	pregnancy complications	3
obstetrics	7	ARDS	3	pregnant women	3
newborn	6	birth	3	remdesivir	3
adult intensive care	5	case report	3	respiratory distress syndrome	3
delivery	5	comorbidity	3	stress	3
epidemiology	5	coronavirus infections	3	transmission	3
infection	5	COVID-19 infection	3		

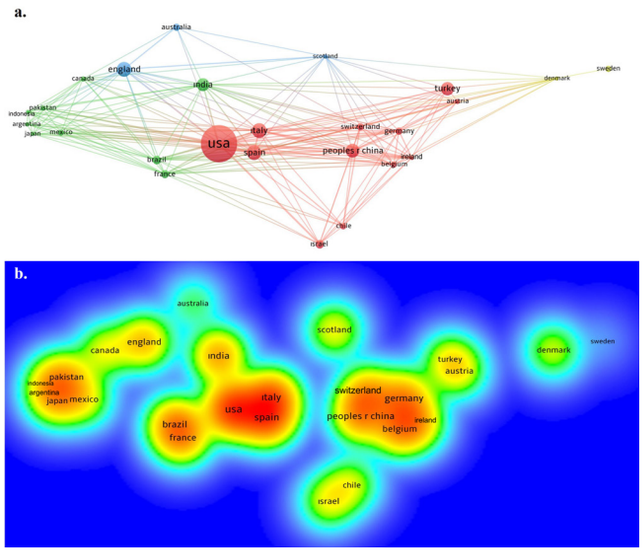

Figure 1. . a. Network visualization map of cluster analysis on international collaboration between countries on study topic. Footnote: Colors indicate clustering. The size of the circle indicates the large number of articles. b. Density map for international collaboration of countries on study topic Footnote: The strength of international collaboration score increases from blue to red (blue-green-yellow-red)

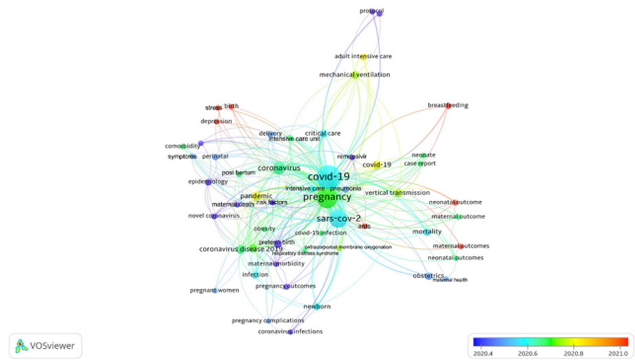

Figure 2. Network visualization map for trends on study topic. Footnote: In the indicator given in the lower right corner of the figure, the topicality of the article increases from blue to red (blue-green-yellow-red). The size of the circle indicates the number of uses of the keyword.

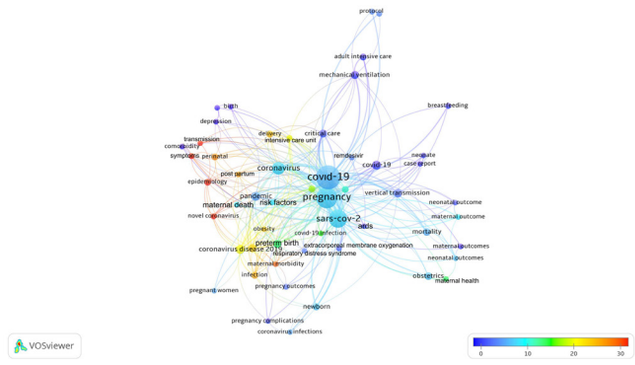

Figure 3. Network visualization map of the most frequently cited topics on study topic. Footnote: In the indicator given in the lower right corner of the figure, the number of citations received by the topic increases from blue to red (blue-green-yellow-red). The size of the circle indicates the number of uses of the keyword.

3.6%), Multidisciplinary Sciences (7, 3.2%), Reproductive Biology (7, 3.2%), Health Care Sciences Services (6, 2.7%), Medicine Research Experimental (6, 2.7%), Public Environmental Occupational Health (6, 2.7%), Endocrinology Metabolism (5, 2.2%), Acoustics(4, 1.8%), Anesthesiology (4, 1.8%), Cardiac Cardiovascular Systems (4, 1.8%), Radiology Nuclear Medicine Medical Imaging (4, 1.8%) and Nursing (3, 1.3%).

1.2. Active Countries

The first 19 countries with the highest number of articles (publishing 5 or more articles) are as follows: USA (71, 32.5%), UK (23, 10.1%), Italy (19, 8.7%), Spain (19, 8.7%), Turkey (17, 7.7%), China (16, 7.3%), India (15, 6.8%), Brazil (10, 4.5%), Israel (10, 4.5%), Australia (8, 3.6%), Iran (8, 3.6%), Belgium (7, 3.2%), France (7, 3.2%), Germany (7, 3.2%), Chile (6, 2.7%), Mexico (6, 2.7%), Switzerland (6, 2.7) %), Argentina (5, 2.2%) and Sweden (5, 2.2%).

Cluster analysis was performed among 26 countries, which produced at least 3 articles from 60 countries that published articles on “pregnant with COVID-19, and critical care”, and whose authors have international cooperation, and it is shown in Figure-1.a. According to the results of the clustering analysis, 4 different clusters related to international cooperation were formed (Cluster-1:Austria, Belgium, Chile, Germany, Ireland, Israel, Italy, China, Spain, Switzerland, Turkey, USA. Cluster-2:Argentina, Brazil, Canada, France, India, Indonesia, Japan, Mexico, Pakistan. Cluster-3: Australia, England, Scotland. Cluster-4: Denmark, Sweden). In addition, the total link strength scores showing the cooperation power of 26 countries were calculated and the International collaboration density map created according to these scores is shown in Figure-1.b.

1.3. Correlation Analysis

There was a high level of statistically significant correlation between the number of articles produced by countries on “pregnant with COVID-19, and critical care” and GDP values, and a moderately positive correlation between GDP per capita values (respectively, r=0.702, p<0.001; r= 0.643, p<0.001).

1.4. Active Authors

The 3 most active authors who published 4 or more articles on that topic were Ferrazzi E. (5, 2.29%), Goffman D. (4, 1.83%), Tayman C. (4, 1.83%), respectively.

1.5. Active Institutions

The 7 most active institutions that have published 5 or more articles on the study topic were University of Milan (9, 4.1%), Tel Aviv University (8, 3.6%), Foundation IRCCS Ca’Granda Ospedale Maggiore Policlinico (Milan) (6, 2.7%), University of Health Science (Turkey) (6, 2.7%), Columbia University (5, 2.2%), King’s College London (5, 2.2%), and Weill Cornell Medicine (5, 2.2%).

1.6. Active Journals

218 articles published on study topic were published in 123 different journals. The top 20 most active journals producing 3 or more articles, the total number of citations received by the journals and the average number of citations per article are presented in Table-1.

1.7. Citation Analysis

Among the 218 articles published on the study topic, the first 15 articles with the highest number of citations, according to the total number of citations, are presented in Table 2.

1.8. Co-citation Analysis

All 218 articles analyzed had a total of 4123 cited studies in the references section. The first 4 studies that received the most co-citations (more than 30 citations) were Chen (2020) (Number of citation:NC=52), Knight (2020) (NC=39), Allotey (2020) (NC=34), and Di Mascio (2020) (NC=31) [1,3,5,13].

1.9. Trending topics

470 different keywords were used in all 218 articles published on the study topic. 54 different keywords that were used in at least 3 different articles are shown in Table-3. Trend network visualization map performed to reveal trend topics is shown in Figure-2 and citation network visualization map performed to reveal the most cited topics is shown in Figure-3.

Discussion

When the distribution of publications of the world countries on the productivity of articles on "pregnant with COVID-19, and critical care" is examined, the countries that published more than 10 active articles were the USA, England, Italy, Spain, Turkey, China, India, Brazil, Israel. Of these countries, 5 were developed and 4 (Turkey, China, India, Brazil) were developing or having large economies. In our study, a high correlation was found between article productivity and GDP, and a moderate relationship between GDP per capita. This shows that the economic size of the countries is effective in the efficiency of publications on "pregnant with COVID-19, and critical care". In bibliometric studies conducted on many different medical subjects, it was concluded that economic power is effective in publication efficiency [6,8,10,12]. Considering the proportion of pregnant who need critical care during the pandemic, it is thought that the consequences of serious viral infection will probably be worse if the number of critical care units is insufficient. Therefore, the economic power of a country will be effective in both academic efficiency and pandemic management. When the density map created according to the total cooperation score between the countries is evaluated, it was determined that the countries with the most intensive cooperation were the USA, Spain, Italy, Germany, China, India, Switzerland, Brazil, Belgium, England, France and Ireland, respectively. When the co-authorship collaborations of countries were examined, it was seen that, contrary to the literature, geographical country-based collaborations did not have a significant effect on article production.

The journals that publish the most articles on the study topic are respectively BMJ Case Reports, International Journal of Gynecology & Obstetrics, American Journal of Perinatology, Cureus, Journal of Maternal-Fetal & Neonatal Medicine, American Journal of Obstetrics & Gynecology MFM, and Journal of Perinatal Medicine. We can recommend that authors who want to publish on this topic, first consider these journals. When the citation analyzes of the journals are evaluated, the most effective journals according to the average number of citations per article they publish are; Ultrasound in Obstetrics & Gynecology, Obstetrics and Gynecology, BJOG-An International Journal of Obstetrics and Gynaecology, Acta Obstetricia et Gynecologica Scandinavica, and the American Journal of Obstetrics and Gynecology. We can recommend that researchers who want their articles to be cited more should primarily consider these journals.

The articles were evaluated according to their total and annual average number of citations. The most influential first study was published in BMJ by Knight et al. [3]. The other most influential studies on this topic was done by Zimmermann and Curtis, Ferrazzi et al., Grohskopf et al. and Collin et al. [14,15,16,17]. Apart from these studies, when the articles are evaluated according to the average number of publications per year, Saccone et al. and Villar et al. were prominent[18,19]. According to the co-citation numbers of all analyzed articles, the studies of Chen, Knight, Allotey, and Di Mascio were determined as the most effective studies [1,3,5,13]. We recommend that clinicians and researchers interested in this subject read these publications first.

As a result of the evaluation of keyword analysis and clustering analysis, it was seen that our study subject was clustered in 6 different colors. The most cited keywords were transmission, symptoms, epidemiology, morbidity, obesity and delivery. According to the results of the analysis made to determine the trend topics, it was determined that the keywords studied in the last months were depression, stress, birth, ARDS, breastfeeding, neonatal and maternal outcomes.

When we evaluated trend issues within the scope of the literature, Chen et al. stated that none of the nine pregnant women in the third trimester included in the study had intrauterine fetal infection due to vertical transmission of COVID-19 infection [1]. In the United Kingdom, it was reported that one out of every 10 pregnant women admitted to the hospital due to SARS-CoV-2 infection needed respiratory support in the critical care unit and 1% of the cases were mortal. Most of the admitted pregnant women were in the second or third trimester, and the transmission rate from pregnant to baby was 5% [3]. A meta-analysis conducted in 2020 revealed that there was no vertical transmission from pregnant to their babies, and that the most common complication in pregnant women was preterm delivery, and the rates of preeclampsia, cesarean section and perinatal death were also increased [13]. In a study conducted in New York in 2021, it was reported that there was no mother-to-baby transmission by being in the same room and breastfeeding [20]. There are studies supporting that SARS-CoV-2 has not been detected in breast milk. As a result of these studies, it is recommended that mothers with COVID-19 continue to breastfeed [1,20,21].

As for outcomes, another trending topic, we can say that maternal deaths, stillbirths, ruptured ectopic pregnancies and maternal depression due to the COVID-19 pandemic have increased, according to the results of a systemic review and meta-analysis conducted in 2021. In this study, the observed increase in maternal mortality was based on data from low-income and middle-income countries. According to the rapid report 'Mothers and Babies: Reducing Risk through Audits and Confidential Inquiries across the UK,' maternal deaths associated with SARS-CoV-2 (9.9 per 100,000) in the first wave of the pandemic (March-May 2020) compared to pre-pandemic (2016-2018)(9.7 per 100,000) was found to be higher [22,23]. In another study evaluating the deaths of mothers with COVID-19, it was found that the risk of mortality was 2 times (RR: 2.26, 95% CI: 1.77-2.89) in pregnant without comorbidity,

and 5 times (RR: 5.09, 95% CI: 2.00-12.98) in pregnant with at least one comorbidity (especially the presence of diabetes and obesity) has been reported to increase [24]. In a study conducted in Mexico, the mortality rate in hospitalized pregnant with COVID-19 was found to be 2.8%, and it was stated that obesity and diabetes increase mortality. However, in this study, unlike the others, it was stated that not all maternal deaths were directly related to COVID-19, and limited health services also contributed to mortality [25]. There are few publications on "pregnant with COVID-19, and critical care" in low and middle-income countries, and it is necessary to support these countries in research in order to create strategies in this regard.

Strengths and limitations of the study

The fact that we used only the WoS database in the literature review in our study is a limitation. Reasons for using only the WoS database are that citation and co-citation analysis that can be done in the WoS database cannot be done in the Pubmed database. The reason why the Schopus database is not used is because journals with lower impact levels are indexed compared to the WoS database.

Conclusion

We shared a summary of 218 articles published between 2019-2021 in this comprehensive bibliometric study on "pregnant with COVID-19, and critical care". It was determined that the trend topics were depression, stress, birth, ARDS, breastfeeding, neonatal outcome and maternal outcomes. By presenting a summary of the global outputs on "pregnant with COVID-19, and critical care", this article can be a useful resource for scientists and clinicians to evaluate treatments and critical care strategies for global viral infections such as SARS-CoV-2 infections.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or compareable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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